1 516 194

PATENT SPECIFICATION

(11) 1 516 194

(21) Application No 28095/75 (22) Filed 3 July 1975
(44) Complete Specification published 28 June 1978
(51) INT CL² B29D 11/00
(52) Index at acceptance
B5A 1F3 1R314C1F 1R442 20T1
(72) Inventors DERRICK KERSHAW
STUART HEAP and
MARTIN SEDDON

(19)

(54) IMPROVEMENTS IN OR RELATING TO CONTACT LENSES

(71) We, KELVIN LENSES LIMITED, a British Company of Kelvin House, Manchester Road, Denton, Manchester, M34 2AH, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to contact lenses and is particularly concerned with providing apparatus for the continuous production of hard contact lenses by moulding and to a process for producing hard contact lenses using the apparatus.

Hard contact lenses have been prepared for many years from synthetic polymers, normally polymethylmethacrylate. Traditionally, these lenses are produced to order from a flat blank by grinding by hand. This hand grinding procedure requires considerable skill and contributes very considerably to the cost of the finished product. Many design improvements have been developed over the years with a view to making the contact lenses more comfortable for the user to wear. These design improvements, which are concerned with giving a good bearing surface without interfering with the corneal metabolism, are designed to provide an efficient tear flow. These design improvements require a variation in the peripheral parts of the lens from the curve that is required for optical reasons in the central part of the lens. To provide adequate edge lift to the lens, it is usually necessary to provide a lens with three different curvatures on the inner bearing surface. In order to provide these improved designs, it is therefore necessary, after the original curvature has been ground into the lens, to grind the modified curvatures on the peripheral parts of the lens and where grinding procedures are used, it is virtually impossible to avoid a ridge or angle at that part of the lens where the degree of curvature changes. These angles or ridges can become pressure points causing pain to the wearer and can impede satisfactory tear flow.

In order to avoid problems of the type described above, we have developed a method of preparing contact lenses having differing degrees of curvature over the surface by moulding rather than by grinding. The use of moulds permits the production of contact lenses in which the bearing surface can be a continuous curve although the degree of curvature of the bearing surface can change from the central portions of the lens to the peripheral portions. In this way, it is possible to achieve all of the advantages of existing lenses in providing adequate tear flow and avoiding interference with corneal metabolism while, at the same time, avoiding the problems caused by the ridges at the boundaries between the sections of different curvature.

In addition to providing a lens which is more comfortable to the wearer, the moulding process of the present invention has the advantage that once the moulds have been prepared, they can be used to prepare a lens of the desired shape much more quickly than it can be produced by grinding and furthermore, that several lenses which are absolutely identical to one another in all respects can be prepared by consecutive use of the same moulds. This represents a considerable step forward from the manufacturing point of view since it enables continuous production of lenses by a moulding procedure which, if desired, can be carried out in a controlled atmosphere from which dust particles are rigorously excluded, a procedure quite impractical in the grinding procedures previously used.

The present invention permits the building up of a bank of contact lenses which can include, if desired, several sets of identical lenses and lenses covering the complete range of lens-types which experience shows are those most commonly required by contact lens wearers. In this

way, it is possible to fit accurately almost every patient requiring contact lenses from the stock of contact lenses and, moreover, to provide further contact lenses which are absolutely identical in all respects to the original lenses in the case where further lenses are required because of loss of the originals.

The present invention provides apparatus for the continuous moulding of contact lenses comprising:

a) means for intermittent movement of a plurality of moulding stations, the intermittent movement permitting the moulding stations to interact with means (b), (c), (d), (e) and (f) defined below;

b) means for feeding a preselected female tool into each of the moulding stations and means for heating the tool to a predetermined temperature,

c) means for feeding a contact lens blank onto each of the female tools heated to the preselected temperature,

d) means for feeding a preselected male tool heated to a preselected temperature onto each of the blanks,

e) means for applying and maintaining a preselected pressure between the male and female tools for a preselected period of time at a preselected temperature,

f) means for cooling the moulding tools containing the moulded lens after a preselected period of time,

g) means for disengaging the male and female tools from one another and releasing the moulded contact lens.

The means for moving the plurality of moulding stations operates intermittently so that the movement stops intermittently preferably for a sufficient period of time for the female tool, the blank, the male tool to be fed to the moulding station and the means for applying the pressure between the tools to operate while the moulding station is stationary. It is possible to feed the moulding station while moving but feeding while stationary is preferred. The means for moving the moulding stations will normally operate so that the moulding stations move at a uniform speed, when they are to be fed while stationary, the stationary period will be long enough for the necessary operations to take place and the speed should be such that the desired period of time elapses between the time when the moulding station leaves the point at which the means for applying the pressure operates and the point at which the means for cooling the tools operates.

A practical arrangement is for the means for moving the moulding stations to be an endless belt, the moulding stations being fixed to the endless belt.

The moulding stations should be spaced apart from one another, in the direction of the movement of the belt, so that with intermittent movement of the belt, the moulding stations can move progressively from the point where the means for feeding the female tool operates, to the point where the means for feeding the blank operates to the point where the means for feeding the male tool operates to the point where the means for applying pressure operates. In order to increase the capacity of the apparatus, in addition to each moulding station having a moulding station to the front and to the rear of itself, in the direction of movement of the belt, it is preferred that each moulding station has an adjacent moulding station which advances in parallel as the endless belt moves forward intermittently. A particularly convenient arrangement is to have a relatively wide endless belt having 4—8 moulding stations in line which all move forward together with the belt.

When the blank has been located between the moulding tools, the moulding station reaches the means for applying and maintaining pressure. This will normally be through a pressure cap which is forced onto the moulding station by a hydraulic or pneumatic ram. The distance through which the moulding pressure acts, which together with the contours of the male and female tools, controls the shape of the final contact lens, may be controlled by a cam. The versatility of the apparatus of the invention resides in the fact that by using a cam controlled ram system, it is possible to control accurately the distance between the male and female tools during the moulding operation. The cam can be made adjustable so that the degree to which it compresses the tools need not necessarily be the same each time the cam is used and, when there are a plurality of moulding stations across an endless belt moving along in line together, the cam setting need not be identical for each moulding station. The cam setting can be controlled manually or automatically so that when more than one cam operates at the same time, the cam settings can be the same or different and each time the cam operates, the cam setting can be the same or different to the setting for the previous operation of that cam.

It is convenient in practice that the heating means for the tools and for the assembled mould should be electrical although other heating means, for example circulating heat exchange fluids, can also be used.

After the moulding procedure, the male and female tools together with the moulded contact lens are cooled normally after ejection of the assembled tools from the moulding station. The cooling can be done on a further moving endless belt where the

moulds are cooled in air or with other heat exchange fluids and the moulding tools recycled for further use.

If desired, the whole apparatus may be enclosed in a dust free clean air atmosphere so that the moulding procedure can be carried out without the risk of the surface of the contact lens being contaminated with dust or other impurities.

In accordance with a further aspect of the present invention, a process is provided for the continuous moulding of contact lenses comprising:

a) intermittently moving a plurality of moulding stations between a series of feed positions, the intermittent movement, permitting the moulding stations to interact in accordance with steps (b), (c), (d), (e) and (f) below:

b) feeding a preselected female tool into each of the moulding stations and heating the tool to a presected temperature,

c) feeding a contact lens blank comprising an incompletely polymerised methylmethacrylate, polymerised to an extent of 80—95% by weight, onto each of the female tools heated to the preselected temperature, the blank being a mouldable thermoplastic that can be moulded under the influence of elevated temperature and pressure to form a moulding that will be dimensionally stable on removal from the mould and in subsequent storage,

d) feeding a preselected male tool heated to a preselected temperature onto each of the blanks,

e) applying and maintaining a preselected pressure between the male and female tool for a preselected period of time at a preselected temperature,

f) cooling the moulding tools containing the moulded lens, after a preselected period of time,

g) disengaging the male and female tools from one another and releasing the moulded lens,

the preselected pressure and temperature of step (e) and the preselected period of time in steps (e) and (f) being such that the polymerisation of the methylmethacrylate is substantially completed while the blank is subjected to the pressure to give a moulding having substantially stable shape and optical properties.

The process of the present invention can be carried out in the apparatus described above. It is important that in the process of the invention, a mouldable thermoplastic material be used which is dimensionally stable on removal from the mould and during subsequent storage. Polymethylmethacrylate materials of the type traditionally used in the production of contact lenses by grinding are not suited to the moulding process of the present invention. This is because these materials are cast rods of high molecular weight completely polymerised methylmethacrylate which cannot be moulded. Cast sheets of the completely polymerised materials of suitable molecular weight can be used to mould lenses but these can exhibit the so-called "plastic memory". This means that when these materials are moulded, they initially adopt the dimension of the mould but on removal from the mould, the curvatures which have been imparted by the moulding process may not be retained accurately and the material shows a tendency to revert to the original flat shape of the blank. However, it has been found that this particular problem can be overcome, using polymethylmethacrylate blanks, by starting with a methylmethacrylate which has been almost completely but not totally polymerised. If the blanks are cut from a sheet of polymethylmethacrylate in which the degree of polymerisation is between 80 and 95% by weight, and particularly 85—90% by weight and the final 5—20% of the polymerisation is completed while the blank is maintained between the moulding tools at elevated temperature and pressure, it has been found that the curvature imparted to the blank during the moulding process is retained after removal from the mould and in subsequent storage. As a practical matter, we find that this final 5—20% polymerisation can be secured at a temperature of 135—145°C in a period of about 3—7 minutes under moulding pressures which are adequate to impart curvatures of the extent required in contact lenses. After completion of polymerisation, the male and female tools are disengaged from one another and the moulded lens released.

The partially polymerised methylmethacrylate material is used for moulding in the process because, not only does it have the desired optical properties, freedom from toxicity and the benefit of being a material with which contact lens manfacturers and users are familiar, but also it is a material that will retain its shape not only under conditions of normal service but also in the event that it is inadvertently allowed to dry out by the user.

The invention will be further described with reference to the accompanying drawings in which:

Figure 1 shows, in side elevation, a schematic view of apparatus in accordance with the present invention and Figure 2 shows a plan view of the same apparatus.

The apparatus comprises an endless belt 1 on which are located a plurality of moulding stations 2. Moulding stations 2 are arranged across endless belt 1 both

transversely and longitudinally. Moulding stations 2 incorporate electrical heaters (not shown in detail) for heating the moulding tools and blank to the desired temperature. Endless belt 1 is arranged under carrier feeder 3, tool feeders 4 and 5, material feeder 6, pressing head 7, compression cap feeder 8 and ejector mechanism 9. Carrier feeder 3 is adapted to feed tool carriers 10 into each of the moulding stations 2 under pressure from pneumatic cylinder 3a, tool feeder 4 is adapted to feed a female tool 11 into tool carrier 10. Material feeder 6 is adapted to feed a contact lens blank 12 onto the female tool. Tool feeder 5 is adapted to feed a male tool 13 onto the contact lens blank 12. Pressing head 7 is adapted to press the male and female tools together, so as to compress and mould blank 12 to the desired shape while compression cap feeder 8 is adapted to fix a compression cap 14 onto the male tool so as to maintain the desired pressure. Ejection mechanism 9 is adapted to eject the assembled tools from the endless belt 1. Cooling conveyor 15, moving in a direction perpendicular to that of belt 1, is positioned to receive the ejected tool assemblies and cooling conveyor 15 is cooled by a stream of cold dust free air to reduce the temperature of the tools and lenses to room temperature.

In operation, endless belt 1 is driven by an intermittently moving motor. As moulding station 2 is positioned under carrier feed 3, a tool carrier is located in the moulding station. The moulding station equipped with carrier then moves forward in one or more movements to tool feeder 4, the speed of belt 1 being such that the temperature of the tool carrier is raised to a sufficiently high temperature by the time the carrier is positioned under the tool feeder. The belt stops under tool feeder 4 and a female tool 11, which may or may not have been pre-heated, is inserted into the tool carrier. Heating of the tool carrier continues as the tool carrier bearing the female tool moves forward in one or more movements to material feeder 6. The time taken for the moulding station to reach material feeder 6 is again adjusted, bearing in mind the necessity of having the carrier and the female tool at the desired temperature. Material feeder 6 then introduces a blank onto the female tool and the belt moves forward once again to tool feeder 5 where a male tool, which also may have been pre-heated, is positioned on top of the blank. Once again, the time taken for the moulding station to move between material feeder 6 and tool feeder 5 is adjusted so that any heating of the tools necessary can be achieved. Once the male tool 13 is in position, the moulding station is moved forward once again and stopped under pressing head 7 where the compression cap from feeder 8 and the tools are pressed together under the influence of a hydraulic ram, controlled by the cam (7a), to subject the blank to the desired moulding pressure. At this stage, the temperature of the assembled mould is normally increased, by 5—10°C by increasing the energy input into the heating means in the moulding stations 2 and the assembled mould moves forward on belt 1 at a speed such that the desired pressure and temperature are maintained for a suitable period of time until the assembled mould reaches ejection mechanism 9. At this stage, the moulds are ejected out onto the cooling conveyor 15 where they are cooled by the stream of cold dust free air. In the embodiment illustrated, the moulding stations are positioned on a movable endless belt and when they move, they will all move at the same speed. A sufficient period of time will therefore be provided between each of the various stages in the process by adjusting the distance between the various feeding means in the apparatus.

Tool feeders 4 and 5 may be stacked with pairs of matched female and male tools. Each moulding station has its own pair of tool feeders and the tools in the pack in the tool feeder may be the same or different. In the arrangement illustrated, where the moving belt contains 6 moulding stations all advancing together, there will be 6 independent tool feeders which may each inject the same or different tools into each moulding station. By appropriate selection of the tools packed into tool feeders 4 and 5, it is possible to produce either the same lenses or different lenses from each of the moulding stations in the group of 6 that are advancing together. Consequently, by appropriate selection of the moulds and appropriate adjustment of the cam settings, it is possible to produce a whole range of lenses of varying powers and curvatures, each lens having a continuous curve but having various degrees of curvature and various thicknesses so that each lens, as produced, can become a component part of a bank of contact lenses from which drawings can be made to fit individual patients.

The following Example is given to describe the invention in further detail.

Contact lenses are prepared in apparatus as illustrated in Figures 1 and 2 of the accompanying drawing. Belt 1 is built up of a series of connected stainless steel links and is of sufficient width to carry a total of 6 moulding stations in line which move forward together. The belt is driven by an electric motor with intermittent drive so

that the belt can be stopped as necessary for loading and unloading of the moulding stations. The moulding blanks are discs of 15 mms. diameter and 0.8 mms. thickness cut from a flat sheet of methylmethacrylate polymer. This sheet is 95% polymerised and includes a dyestuff of the type conventionally used in polymethylmethacrylate sheet to be used for contact lens manufacture. The male and female tools are pre-machined in stainless steel, hardened tool steel, or ceramic to predetermined curvatures and matched pairs of the tools are packed into tool feeders 4 and 5.

Belt 1 moves forward under carrier feeder 3 when carrier 10 is positioned in each of the moulding stations. Belt 1 then moves forward and stops under tool feeder 4 when each moulding station is supplied with a female tool. The speed of the belt and the temperature of the heaters are such that the carrier 10 and female tool 11 are at a temperature of 130°C upon receipt of material blank 12. The belt moves forward again but stops under material feeder 6 where the blanks of polymethylmethacrylate are inserted on top of the female tool. Belt 1 moves forward and stops again under tool feeder 5 where a male tool, pre-heated to 130°C is positioned on top of the blank and the assembled mould then moves forward and stops under pressing head 7 where compression cap 14 is applied and the tools are pressed together. The extent of electrical heating is then increased so that the assembled mould achieves and is maintained at a temperature of 140°C. and the assembled mould moves forward towards ejection mechanism 9 which it reaches after five minutes. At this stage, the assembled tools containing the moulded lens are ejected onto cooling conveyor 15 where they are cooled to room temperature by the stream of cold dust free air. It is found that the moulded lenses exhibit a perfect reproduction of the moulding surfaces and that the curvature imparted to the lens during the moulding process is retained by the lens when it is subjected to normal contact lens service.

By appropriate selection of tools and of moulded thickness, a series of contact lenses of any normal specification can be prepared. Typical lenses are those having lens powers in the range −20 to +20 diopters and having centre thicknesses in the range 0.1—0.5 mm. In order to build up a bank of lenses of appropriate prescription, tools of back central optic radii of for example 7.0—8.5 mm. are prepared, having back surfaces which are spherical or toroidal in shape. Lenses produced by the moulding process of the present invention will normally have overall diameters of 9.0—9.5 mm and the process can be used to produce typical toric lenses 6.5×7.0 mm up to 8.5×8.0 mm.

WHAT WE CLAIM IS:—

1. Apparatus for the continuous moulding of contact lenses comprising

a) means for intermittent movement of a plurality of moulding stations, the intermittent movement permitting the moulding stations to interact with means (b), (c), (d), (e) and (f) defined below;

b) means for feeding a pre-selected female tool into each of the moulding stations and heating the tool to a predetermined temperature,

c) means for feeding a contact lens blank onto each of the female tools heated to the predetermined temperature,

d) means for feeding a pre-selected male tool heated to a pre-selected temperature onto each of the blanks,

e) means for applying and maintaining a pre-selected pressure between the male and female tools for a pre-selected period of time and a pre-selected temperature,

f) means for cooling the moulding tools containing the moulded lens after a pre-selected period of time,

g) means for disengaging the male and female moulding tools from one another and releasing the moulded contact lens.

2. Apparatus according to Claim 1 wherein the time for which the pre-selected pressure between the tools is maintained is controlled by the speed of movement of the moulding stations.

3. Apparatus according to Claim 1 or 2 wherein the means for moving the moulding stations comprises an endless belt on which each of the moulding stations has a moulding station positioned in front, a moulding station positioned behind and a moulding station positioned to the side.

4. Apparatus according to any one of the preceding Claims, having means for applying a pressure cap hydraulically or pneumatically to maintain the pressure between the tools.

5. Apparatus according to Claim 4, wherein a cam controls the distance over which the means for applying and maintaining pressure between the tools operates.

6. Apparatus according to Claim 5, wherein the cam setting is uniform for each moulding station.

7. Apparatus according to Claim 5, wherein the cam setting is different for each moulding station.

8. Apparatus according to any one of the preceding Claims, wherein electrical heating means are provided to heat the tool and the blanks.

9. Apparatus according to Claim 1, substantially as hereinbefore described with reference to the accompanying drawings.

10. A process for the continuous moulding of contact lenses comprising a) intermittently moving a plurality of moulding stations between a series of feed positions, the intermittent movement, permitting the moulding stations to interact, in accordance with steps (b), (c), (d), (e) and (f) below:

b) feeding a pre-selected female tool into each of the moulding stations and heating the tool to a pre-selected temperature,

c) feeding a contact lens blank comprising an incompletely polymerised methylmethacrylate, polymerised to an extent to 80—95% by weight, onto each of the female tools heated to the preselected temperature, the blank being a mouldable thermoplastic that can be moulded under the influece of elevated temperature and pressure to form a moulding that will be dimensionally stable on removal from the mould and in subsequent storage,

d) feeding a preselected male tool heated to a preselected temperature onto each of the blanks,

e) applying and maintaining a preselected pressure between the male and female tool for a preselected period of time at a preselected temperature,

f) cooling the moulding tools containing the moulded lens, after a preselected period of time,

g) disengaging the male and female tools from one another and releasing the moulded lens,

the preselected pressure and temperature of step (e) and the preselected period of time in steps (e) and (f) being such that the polymerisation of the methylmethacrylate is substantially completed while the blank is subjected to the pressure to give a moulding having substantially stable shape and optical properties.

11. A process according to Claim 10, wherein the female tool, blank and the male tool are fed and the pressure on the assembled tools applied when the moulding stations are stationary.

12. A process according to Claim 10 or 11 wherein the period of time for which the preselected pressure between the tools is maintained is controlled by adjustment of the speed of movement of the moulding stations.

13. A process according to any one of Claims 10—12 wherein the moulding stations are moved on an endless belt on which each moulding station has a moulding station positioned in front, a moulding station positioned behind and a moulding station positioned to the side.

14. A process according to any one of Claims 10 to 13 wherein the pressure on the assembled tools is applied and maintained by applying a pressure cap hydraulically or pneumatically.

15. A process according to Claim 14 wherein the distance over which the pressure on the assembled tools is applied is controlled by a cam.

16. A process according to Claim 15, wherein the cam setting is uniform for each moulding station.

17. A process according to Claim 15, wherein the cam setting is varied for each moulding station.

18. A process according to any one of Claims 10—17 wherein the tools and blanks are heated electrically.

19. A process according to any one of Claims 10—18, wherein during step (e) a temperature of 135—145°C is maintained for a sufficient period of time to complete polymerisation.

20. A process according to Claim 19, wherein the degree of polymerisation in the blank is 85—90% and a temperature of 140°C is maintained for 5 minutes during step (e).

21. A process according to Claim 10, substantially as hereinbefore described with reference to the Example.

22. A contact lens obtained by a process according to any one of Claims 10—21.

J. A. KEMP & CO.,
Chartered Patent Agents,
14, South Square,
Gray's Inn,
London, WC1.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1978
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1516194 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

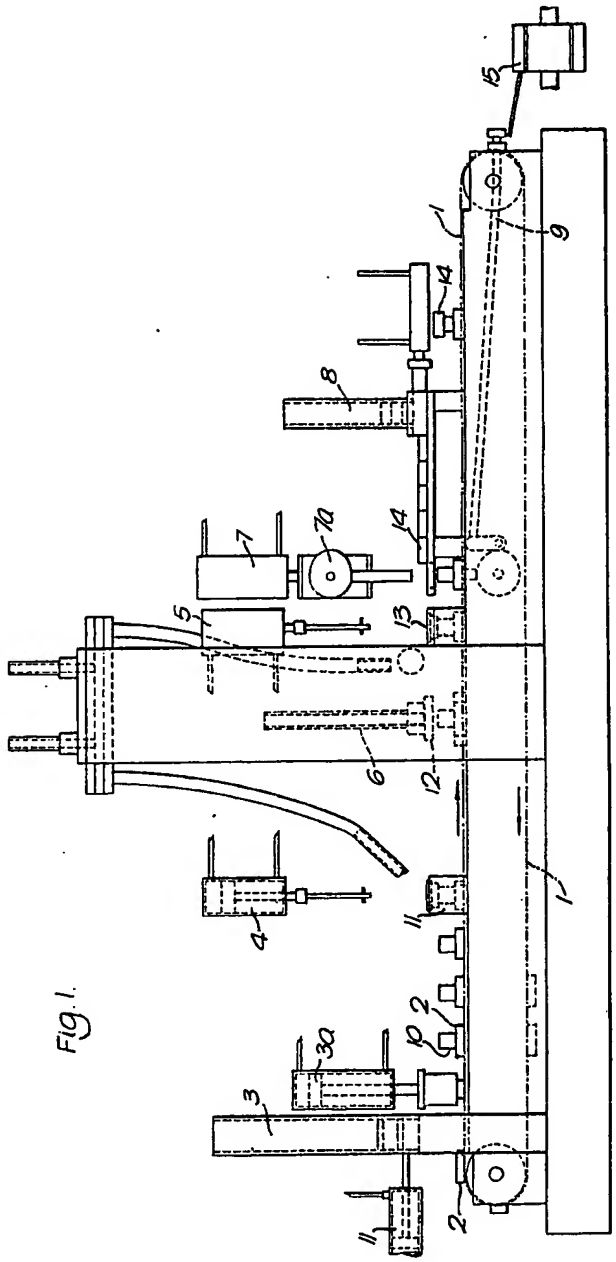

Fig. 1.

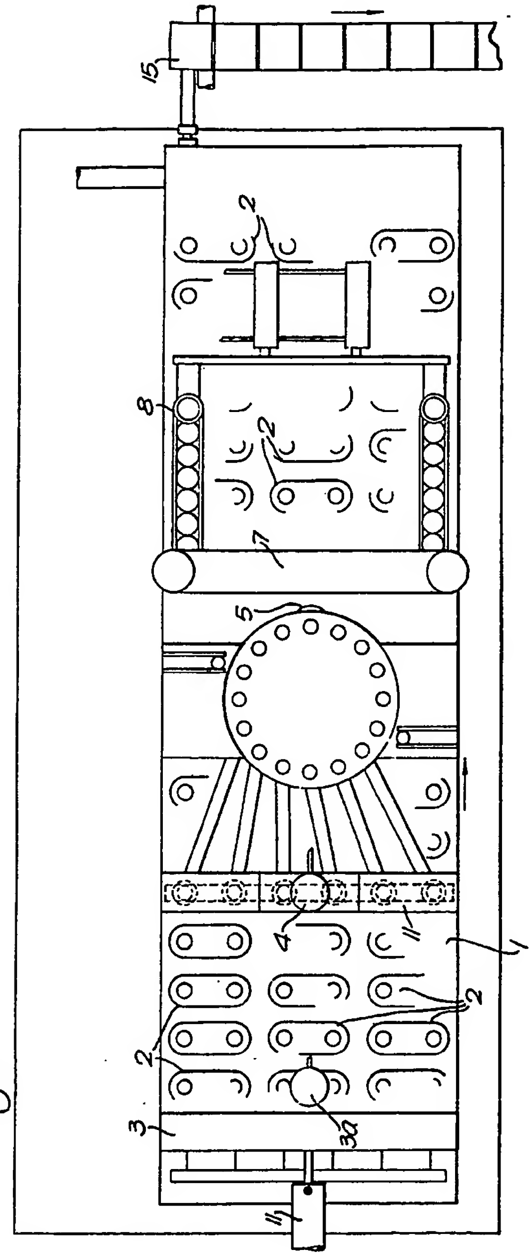

Fig. 2.